



Prioritized Technology: Ice Penetration and Sampling – Low-Mass, Low-Power Excavation

Technical Goal

Establish one or more methods to extract samples from ice (with possible salts, sulfur and biomolecules) in Ocean Worlds at progressively increasing depths, eventually all the way to the liquid water:

- Pristine as possible (at least at micro-scale)
 - Reduce cross-contamination
 - Must tolerate sulfur-rich environment (e.g. sulfuric acid)
- Landed missions expected to have saws, drills, melt-probes, etc. deployed from within the lander body onto or into the ice.

Mission Applications

- Discovery of macromolecules indicating extant life may exist can be looked-for in water that periodically erupts onto the surface and freezes, or in convecting ice, or in the liquid water ocean. Intermediate depths (Class 2) may also be of interest, e.g. if Titan has layered deposits. Also, Enceladus plume vents may be explored, including down to liquid water.
- Low probability of contamination of the sample during mission to meet COSPAR and eliminate chance misinterpreting earth life as alien life
- Class 1 enables sampling of pristine material, e.g. almost entirely unaffected by the radiation environment of Europa.
 - Significantly deeper than the planned Europa lander at ~10 cm.
- Class 2 enables sampling of possible layered terrain on Titan, and completely unaffected by radiation (including Galactic Cosmic Rays)
 - At the limit of depths that might be achieved using techniques that "line the hole" to prevent collapse all the way to the desired depth.
- Class 3 enables sampling of liquid water from the oceans or in convecting ice that has been in contact with the liquid oceans in the relatively recent past
 - Convection zone on Europa likely to be at least one or a few km depth.

Technical Status

- Europa lander pre-project has conducted many experiments of cutting cryogenic ice, mostly with saws.
- 3D-printed 316 stainless saw blade has cut -85C ice.
- Many approaches exist for sampling between 0.2 and 2 meters: circular or chain saws, heated blades or scoops, etc.
- Wireline drills allow open-hole drilling or coring without lining the hole in formations where mechanical properties allow a hole to remain open without lining.
- Novel approaches to melt probes (e.g. putting heat source in Dewar to eliminate horizontal heat leak) may allow deep penetration within mass/power/volume limits.

Development Cost and Schedule